RADIO RESEARCH COMMITTEE

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

Progress Report

SEPTEMBER 1955 - FEBRUARY 1956

सत्यमेव जयते

INDIAN NATIONAL COMMITTEE FOR THE URSI
NATIONAL PHYSICAL LABORATORY, NEW DELHI-12, INDIA

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C O N T E N T S

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RADIO RESEARCH COMMITTEE MEMBERSHIP

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	Dr M.B. Sarwate
	Professor K. Sreenivasan
Secretary :	Dr A.P. Mitra

PREFACE

The Radio Research Committee of the C.S.I.R. is in some respects different from other research committees, since, in addition to the normal work pertaining to such committees, it functions as the National Committee in India for the International Scientific Radio Union (URSI). It also works in collaboration with the Indian National Committee for the International Geophysical Year, and has recently established its own Research Centre at its secretariat.

During the period under review the committee has sponsored twenty research schemes of which one was new. The subjects covered by such schemes were mainly (1) Ionospheric Propagation, (2) Atmospherics, (3) Microwaves and (4) Electronics Instrumentation Development Work.

In India there is now a network of seven regular ionospheric stations, to which Trivandrum (situated at the geomagnetic equator) will soon be added. Most of these receive either full or partial assistance from the committee. Measurements of ionospheric absorption have been made at Ahmedabad and Haringhata-Calcutta, and of drift at Ahmedabad, Banaras and Waltair. Scatter experiments have been undertaken at Banaras using high power transmission from A.I.R., Delhi, and the local pulse transmitter. Construction of high precision ionospheric height measuring equipment was continued in Calcutta (Mr B.M. Banerjee).

In the subject of atmospherics, wave forms of a large number of atmospherics were studied at Banaras and Poona over a wide frequency range in the low and very low frequency band. At Banaras the possibility of locating sources of atmospherics by a single station was explored.

In the field of microwaves, the main emphasis at present is on the study of absorption and dielectric properties at these frequencies. This work has been continued in Allahabad, Lucknow and Waltair, and initiated at Roorkee. In addition, microwave propagation has been undertaken at Bangalore.

On the instrumentation side, work on millimicrosecond pulse generators and pulsive tube characterist

meters was continued at the Madras Institute of Technology, and the construction of 100 Watt R.C. type F.M. oscillator at the Bengal Engineering College, Howrah was completed. Work was also continued at the National Physical Laboratory on the manufacture of capacitors and the development of the manufacturing process.

At the committee's own research centre at the Secretariat, research was confined to problems of radio propagation. Since January, 1955 the Secretariat has been publishing the monthly bulletin on Ionospheric Data which now contains the hourly data of seven ionospheric stations, the actual radio propagation data over Bombay-London circuit and the solar and magnetic data obtained at Kodaikanal. Experimental study of ionospheric absorption and drift by radio astronomical techniques has been taken up, and solar terrestrial relationships for stations within the geomagnetic anomaly have been investigated. The possibility of strong vertical drifts causing temporary breaking of the E-layer at times of strong magnetic disturbance is being quantitatively explored. A new method has been developed to study oxygen dissociation in the high atmosphere from the observational results on effective recombination coefficient for day and night conditions.

I take this opportunity to thank the Investigators-in-Charge of the various schemes for supplying material for the publication of this report. I would also like to record, on behalf of the Committee, our appreciation for the work done by Mr C.L. Kesavan in the preparation of this report.

A. P. Mitra

(A.P. Mitra)
Secretary, Radio Research
Committee

A. PROGRESS REPORT
ON
RESEARCH SCHEMES SPONSORED BY THE COMMITTEE

LIST OF SCHEMES

COMMISSION I.

1. Absorption of microwaves in the 3cm. region - Mr Krishnaji, Allahabad University.

2. Absorption and dielectric properties in the microwave region - Prof. P.N. Sharma, Lucknow University.

3. Microwave technique and its applications - Dr Rangadhama Rao, Andhra University, Vishakhapatnam.

4. Measurements of dielectric constants at microwave frequencies - Mr P.V. Indiresan, Roorkee University.

COMMISSION II.

1. Investigations on microwave propagation - Professor K. Sreenivasan, Indian Institute of Science.

COMMISSION III.

1. Ionospheric Investigations - Prof. S.K. Mitra, Institute of Radiophysics and Electronics.

2. Recording and analysis of reflection of electromagnetic waves from the ionosphere at Ahmedabad - Dr K.R. Ramanathan, Physical Research Laboratory.

3. Scattering of Radio Waves - Dr S.S. Banerjee, Banaras Hindu University.

4. Lunar and solar tides in the ionosphere - Mr B.M. Banerjee, Institute of Nuclear Physics, Calcutta

5. Travelling wave disturbances in the ionosphere by spaced receiver method - Dr B. Ramchandra Rao, Andhra University.

6. Study of winds in the Ionosphere - Dr S.R. Khastgir, Banaras Hindu University.

7. Study of wind drifts in the E and F layers of the Ionosphere - Mr U.D. Desai, Physical Research Laboratory.

8. Design and construction of ionospheric recorder - Prof. K. Sreenivasan, Indian Institute of Science.

9. The Physics of the Lower Ionosphere - Dr A. P. Mitra, Secretary, Radio Research Committee.

COMMISSION IV.

1. Study of nature of atmospherics - Dr S.R. Khastgir, Banaras Hindu University.

2. Nature and origin of atmospherics - Dr M.W. Chiplonkar, Poona University.

COMMISSION V.

No Scheme.

COMMISSION VI.

1. Construction of 100 watt R-C-type F.M. Oscillator - Prof. H. Rakshit, Bengal Engineering College.

2. Millimicrosecond pulse generator - Mr P.V.V.S. Sastry, Madras Institute of Technology.

3. Pulsive Tube Characteristic Meter - Mr P.V.V.S. Sastry, Madras Institute of Technology.

COMMISSION VII

1. Project on manufacture of Radio Components in the National Physical Laboratory.

COMMISSION I: ON RADIO MEASUREMENTS AND STANDARDS

1. Absorption of microwaves in the 3 cm. region - Mr Krishnaji, Allahabad University.

2. Absorption and dielectric properties in the microwave region - Professor P.N. Sharma, Lucknow University.

3. Microwave technique and its applications Dr Rangadhama Rao, Andhra University.

4. Measurements of dielectric constants at microwave frequencies - Mr P.V. Indiresan, Roorkee University.

ABSORPTION OF MICROWAVES IN 3 CM. REGION

Mr Krishnaji (Investigator-in-Charge)

Mr Ganesh Prasad Srivastava

Mr Bhola Nath Mehrotra

I. Technique for bending wave guides into desired shapes without causing excessive reflection has been developed. Woods metal (Bi 55.74 %; Cd 16.80% ; Pb 17.73% ; Sn 13.73% - melting point 75°C approx.) is filled inside the wave guide at a temperature of about 80°C and is allowed to cool and solidify. The wave guide is then carefully bent and the alloy is then melted out by heating the wave guide. The bent pieces of wave guide have highly satisfactory value of V.S.W.R. One such piece of 7 feet was made into a U-shaped cell so that it could be kept inside the constant temperature hot bath and deep freeze. Its V.S.W.R. is as good as 1.06. This wave guide cell and the improved technique described in the last report were used for measuring the temperature variation of electric susceptibility of several gases in the 3 cm. region. Table I gives representative set of data for C_2H_5Cl.

II. The improved set up was also utilised for measuring absorption coefficient of several gases (NH_3, C_2H_5Cl, CH_3Cl, $C_2H_5NH_2$, CH_3NH_2 etc.) for 3 cm waves at different temperatures. Table II shows a representative set of data for ethyl chloride vapour.

TABLE I

Variation of electric susceptibility with temperature.

Substance - Ethyl Chloride

PRESSURE	WAVELENGTH	ELECTRIC SUSCEPTIBILITY $X_o \times 10^3$ AT DIFFERENT TEMPERATURES (C).					
Gms of Hg	cms.	33.7	41.0	48.9	60.4	70.4	81.4
10	3.42	1.75	1.65	1.60	1.45	1.40	1.30
20	3.42	3.55	3.35	3.20	2.90	2.75	2.60
30	3.42	5.35	5.00	4.75	4.25	4.15	3.90
40	3.42	7.15	6.75	6.35	5.65	5.50	5.20
50	3.42	8.95	8.50	7.95	7.10	6.85	6.50
60	3.42	10.75	10.20	9.55	8.55	8.20	7.80

TABLE II

Variation of Absorption Coefficient with temperature

Substance :- Ethyl Chloride

PRESSURE	WAVELENGTH	Absorption coefficient X 10^4/cm at different temperatures (°C)					
Cms.of Hg	cms.	33.7	42.1	49.8	60.0	71.4	84.4
25	3.42	1.00	0.40	0.30	0.25	0.20	0.15
30	3.42	1.35	0.60	0.55	0.35	0.25	0.20
35	3.42	1.80	0.80	0.75	0.50	0.45	0.35
40	3.42	2.20	1.20	1.10	0.80	0.75	0.55
45	3.42	2.70	1.65	1.45	0.95	0.90	0.75
50	3.42	3.15	2.15	1.90	1.35	1.30	1.05
55	3.42	3.70	2.70	2.40	2.10	1.80	1.45
60	3.42	4.25	3.30	3.00	2.65	2.30	1.95
65	3.42	5.05	4.00	3.65	3.50	3.05	2.55
70	3.42	5.80	5.00	4.50	4.30	3.95	3.30

At a given pressure the expression for δ can be modified to

$$\left[\frac{R.\delta T}{3p} - A \right] .T = B'$$

A graph between δT and $1/T$ was plotted for Ethyl Chloride. The graph is a straight line from which the values of the following constants were determined.

$A = 11.8/cc$

$B' = 30.77 \times 10^3$

It is known that microwave absorption coefficient varies with temperature as follows :

$$\alpha' = \alpha_2 (T_2/T_1)^x$$

To determine the value of x a graph was plotted between log α and log T. The value of x at different pressures for Ethyl Chloride is shown below.

Pressure cms.	x
25	5.5
45	3.2
65	2.2

III. Further development in the technique of making wave guide components was made. The following items were successfully made.

a. 90° E- plane bends.

b. 90° Twists.

c. Sliding screw Tuners.

d. Directional Coupler.

Arrangements are being made for making X-band rectangular wave guides upto 16 feet from circular pipes.

The following papers have been sent for publication.

1. A note on Microwave Spectrum of Methyl Bromide- Prem Swarup - Zeit. fur Physik, 154, 1956.
2. Dielectric Behavior of mixture of Polar Gases at Microwave Frequencies - G.P. Srivastava - Curr. Sc., 25, 111, 1956.
3. Variation of Dielectric Constant with Temperature - G.P. Srivastava and Y.P. Varshni - Physica, 22, 111, 1956.

STUDY OF ABSORPTION AND DIELECTRIC PROPERTIES IN THE MICROWAVE REGION

Dr P.N. Sharma (Investigator-in-Charge)
Mr Aravind Vyas

Since our interests were originally directed towards the investigation of dielectric properties of Thermoplastic Resins of indigenous origin, we have endeavoured to obtain genuine, graded samples of other such resinous materials. Since ROSIN is an, important thermoplastic resin obtained as a cheap by-product in Turpentine Oil Industry in India and is widely used as an adultrant in Shellac Industry, we have sought to investigate its dielectric properties at Microwave Frequencies. We have selected the following eight grades of ROSIN for conducting our work :

1.	WW	5.	K
2.	WG	6.	G
3.	N	7.	S
4.	M	8.	B

These were supplied by the Government Turpentine and Rosin Factory, Clutterbuckganj, Bareilly.

Technique for the preparation of ROSIN- samples :

It is necessary for our investigations using the Short-circuited-Line method invorporating the Standing-Wave technique that the sample under investigation should

be obtainable in solid form having its rectangular cross-section equal to that of the Wave-guide so that an exact or nearly exact fit is obtained. It is also essential that the two sides of the samples perpendicular to the direction of the microwave beam should be nearly plane parallel. Hence great care has to be excercised in the preparation of these samples in order to ensure high degree of accuracy in the results obtained.

ROSIN is first carefully melted in an oil-bath taking good care that the temperature does not rise much above the melting point as this would tend to decompose the substance. Molten Rosin is then decanted into a specially prepared cast whose sides have been thinly lubricated. Samples so prepared have to be carefully filled in order to fulfil the above-mentioned requirements. But since, when solid, Rosin is a very brittle substance which cannot be filed without breaking it into pieces, a special technique has to be applied for this purpose. The sample obtained from the cast is carefully rubbed over a piece of cloth over which some Benzen has been sprinkled. After the dimensions of the sample have very nearly approached the required dimensions, it may be carefully applied to the Emery Polishing Paper, grades 1 and 0, till a close fit in the wave-guide is obtained. The prepared samples are then transferred to a desiccator

and kept therein for at least 24 hours prior to experimentation.

Accurate samples have been prepared by this technique for the abovementioned grades of Rosin.

Experimental Procedure :

As in our investigations on Seed-lac we are employing the short-circulated-line method incorporating the use of a short-circuiting plunger and a standing-wave-detector. We have obtained a 3 Kc/s Square Wave Modulator and a 3 Kc/s selective amplifier unit. With the help of these instruments we expect to obtain a still higher accuracy in our results.

A preliminary value has already been obtained both regarding 'K' and 'tanδ' with some samples. Detailed work is now in progress.

MICROWAVE TECHNIQUE AND ITS APPLICATIONS

Prof. K. Rangadhama Rao, (Investigator-in-Charge)
Mr Radhakrishna Murty,
Mr K.V. Gopalakrishna and
Mr D.V.G.L. Narasimha Rao.

A. Technique.

After completing the design and construction of various 3 cm. microwave components referred to in the previous report, a variable flap attenuator with approximately 20 db attenuation for 3 cm. has been constructed during this period. The design and construction of a cavity resonator for studying the properties of liquid dielectrics in the 3 cm. region is in progress. After its completion it is proposed to use it for the measurement of $\tan\delta$ for a number of pure liquids and dilute solutions to supplement the results obtained with waveguide techniques.

B. Applications.

After determining the dipole moment and relaxation time of a number of liquids in dilute solutions as reported previously, the values of μ and τ are determined for phenol, ortho and para chlorophenol, aniline and meta chloroaniline and benzyl alcohol to examine the occurrence of segment orientation of liquid molecules

in dilute solutions. The variation of γ with viscosity has also been investigated for phenol and chlorophenol in the benzene-paraffin mixtures. The results of these experiments will be communicated shortly for publication.

Of special interest is the determination of the dipole moments of some substituted benzenes and pyridines for which there are no values. This work is completed and a preliminary note has been sent to J.S.I.R. and has been accepted for publication.

The μ and γ of 2:4 Dinitro-fluorobenzene have been determined in dilute solution at 3 cms. The dipole moment is determined by r.f. measurements also and the results have been published.

A number of useful formulae have been worked out for the calculation of the dipole moments of tetra substituted benzenes from the group moments. The results have been communicated.

A new method has been worked out for the determination of ϵ' and ϵ'' from impedance measurements at u.h.f. A paper has been communicated incorporating these results.

The list of papers published and communicated is given below :

1.(a) On the determination of dipole moment and relaxation time at 3 cms. Curr. Sci., 1956, 25, 49

(b) " " " J.S.I.R. (Communicated)

2. Relaxation time and dipole moment of monohalogenated benzenes, J.S.I.R. (Recommended for Publication)

3. Dipole moments of some substituted benzenes and pyidines, J.S.I.R. (Recommended for publication)

4. Dielectric properties of 2 4 Dinitro fluorobenzene, Ind. Journ. Phys. 1956, <u>30</u>, 91.

5. Dielectric behaviour of ethyl acetate at u.h.f., Curr. Sci., 1956, <u>25</u>, 49

6. Calculation of the dipole moments of tetra substituted benzenes, Ind. Jour., Phys. (Communicated)

7. A new methodfor computing the complex dielectric constant from u.h.f. impedance measurements. Trans. Farad. Soc. (Communicated)

MEASUREMENTS OF DIELECTRIC CONSTANTS AT MICROWAVE FREQUENCIES

Mr P.V. Indiresan (Investigator-in-Charge)

The Klystron power supply unit has been constructed, tested and found satisfactory. The fabrication of microwave components has now been taken on hand.

It is proposed to take on hand the construction of a modulator and detector unit for the 723 A/B klystron, as also the fabrication of microwave cavities, klystron mounts and detecting sections.

COMMISSION II: ON RADIO AND TROPOSPHERE

*1 Investigation on microwave propagation - Prof. K. Sreenivasan, Indian Institute of Science, Bangalore.

* Preliminary work has been started.

COMMISSION III: ON IONOSPHERIC RADIO

1. Ionospheric Investigations - Prof. S.K. Mitra, Institute of Radiophysics and Electronics, Calcutta 9.

2. Recording and analysis of reflections of electromagnetic waves from the ionosphere at Ahmedabad - Dr K.R. Ramanathan, Physical Research Laboratory, Ahmedabad.

3. Scattering of radio waves - Dr S.S. Banerjee, Banaras University.

4. Lunar and Solar tides in the ionosphere - Mr B.M. Banerjee, Institute of Nuclear Physics Calcutta 9.

5. Travelling wave disturbances in the ionosphere by spaced receiver method - Dr B. Ramachandra Rao, Andhra University.

6. Study of winds in the ionosphere - Dr S.R. Khastgir, Banaras University.

7. Study of winds drifts in the E and F layers of the ionosphere - Mr U.D. Desai, Physical Research Laboratory, Ahmedabad.

8. Design and construction of ionospheric recorder - Prof. K. Sreenivasan, Indian Institute of Science, Bangalore.

9. Physics of the Lower Ionosphere - Dr A.P. Mitra.

IONOSPHERIC INVESTIGATIONS

Prof. S.K. Mitra (Investigator-in-Charge)

Dr S.S. Baral,
Mr R.K. Mitra,
Mr A.K. Saha,
Mr S. Roy and
Mr S. Datta.

1. P'-f records at 10 minutes intervals were obtained regularly with the automatic ionospheric recorder installed at Haringhata.

2. P'-f records were scaled regularly at 30 minutes intervals and the following ionospheric characteristics were tabulated :

   f_{min}, foE, fEs, foF1, foF2, fxF2, h'E, h'F2, hpF2 and M(3000)F2.

   Hourly values of the following characteristics were communicated to the Radio Research Committee at the end of every month.

   foE, fEs, foF1, foF2, h'E, h'F1, h'F2 and hpF2.

   Since January, 1956 the values of (M3000)F2 are being sent in place of hpF2.

3. Critical study of the P'-f records are being continued.

4. Manual measurement of ionospheric absorption at vertical incidence was continued. Work has been started on the construction of an automatic apparatus for ionospheric

absorption measurement at Haringhata.

5. Work on the construction of an apparatus for measuring ionospheric drifts by the spaced aerial technique has also been started.

The following notes have been published or communicated :

1. Some features of the E2 layer observed at the Ionosphere Field Station, Calcutta - A.K. Saha and S. Roy, Jour. Terr. Phys. Vol. 7, p.107, 1955.

2. Some features of P'-f records obtained at Haringhata A.K. Saha and S. Roy, Science and Culture, Vol. 21 p.111, 1955.

3. Electric Collisional frequency in the F-region over Calcutta - S. Datta, Ind. Jour. Phys., Vol. 29, p. 279, 1955.

4. Ionospheric observations during the solar eclipse of June 20, 1955 - A.K. Saha, S. Roy, S. Datta and R.K. Mitra - Science and Culture, Vol.21, p. 475, 1956.

5. Studies on Ionospheric Prediction - S.S. Baral (in Press).

RECORDING AND ANALYSIS OF REFLECTIONS OF ELECTROMAGNETIC WAVES FROM THE IONOSPHERE AT AHMEDABAD

Dr K.R. Ramanathan (Investigator-in-Charge)

Mr K.M. Kotadia,
Mr R.G. Rastogi and
Mr J.S. Shirke.

Mr R. Sethuraman who joined the laboratory as Jr. Research Assistant in September, 1955 has been transferred to work on the scheme of Ionospheric winds. Mr J.S. Shirke came in his place on the 24th January, 1956.

As usual, the Ionospheric Recorder was maintained in proper working condition.

1. Ionospheric Data : The daily ionospheric data entered in monthly tables were sent regularly for publication in the Bulletin of the Radio Research Committee of the C.S.I.R. These tables give heights and critical frequencies of E, F_1, F_2 and E_s layer.

2. Solar Eclipse of 14th December, 1955 : By special arrangement with the All India Radio, observations of field strength of signals in the 31 m and 41 m bands from Bombay were made at Ahmedabad during the eclipse of the 14th December, 1955 and also on Control days. Vertical incidence ionospheric records were also obtained at short intervals on the above days. The effect of the eclipse was to cause a decrease in electron density in the E and

F_1 layers.

3. A strong solar flare effect was observed on the 23rd February, 1956 as seen from the hourly record of 0900 hr 75° E.M.T. The signals at vertical incidence below 10 Mc/s were completely absorbed and reception at oblique incidence from all radio stations faded out. The flare effect was also recorded on the cosmic noise record at 25 Mc/s., which showed almost complete fade-out at 0834 hr., 75° E.M.T A note describing the effect of this big flare on the Innosphere, cosmic radio noise and cosmic ray intensity will be published shortly.

4. A paper entitled 'Sporadic echoes from the E region during sunspot minimum period 1953-1954 at Ahmedabad' by Mr. K.M. Kotadia has been accepted for publication in the Jour. Atmosph. Terr. Physics. An account of the behaviour of the Ionospheric E_2 layer at Ahmedabad during 1953-54 by Mr Kotadia is now being finalised for publication. Analysis of the midday (10-14 hrs.) critical frequencies and heights of the F2 layer for 1954-1955 is under progress to study their variation with lunar phase. The lunar variation at Ahmedabad is also being compared with the variation at other low latitude stations.

5. Mr Rastogi made a study of the changes in field strengths observed on different frequencies from distant

stations at Ahmedabad and by workers elsewhere and has prepared a detailed note on the subject.

Ionospheric records taken at short intervals for the study of special features in the behaviour of the F_2 regions over Ahmedabad were analysed.

Special observations were taken during thunderstorms to study their effect on E_s ionisation.

6. Mr J.S. Shirke has started work to build up equipment for the measurement of Ionospheric absorption at vertical incidence on some fixed frequencies.

SCATTERING OF RADIO WAVES

Dr S.S. Banerjee (Investigator-in-Charge)
Dr D.K. Banerjee

During the period under review the variation of intensity of scattered signals with time has been studied for transmission from the high power transmitter at A.I.R. Delhi and of the back-scattered echoes using a pulse transmitter in the laboratory.

The optimum distance for the maximum intensity of the back-scattered echoes from the ground as the frequency of transmission is increased, has been theoretically calculated on the basis of the focussing effect due to the thickness of the ionosphere as suggested earlier. The theoretical considerations show that after the appearance of the back scattered signals the intensity increases to maximum and then falls exponentially. The maximum intensity is obtained when the scattering centres lie at a distance of $2\sqrt{h(t+h)}$ from the transmitter, h and t being respectively the height and semi-thickness of the ionospheric layer. This has been generally varified by experimental results, but sometimes the intensity shows a temporary rise after the occurrence of the first maximum as described above. This additional rise of intensity of scattered signals may, however, be due to

the irregularities either in the ionosphere or in the nature of the terrain producing the scattered signals.

Besides the above observations on the variation of the intensity of the back-scattered echoes it was found that the scattered signals from the same bi-directional transmitters at Delhi were invariably of higher intensity in the morning than in the evening hours. This has been attributed to the possibility of two entirely different types of terrain from which these scattered signals originated, viz., from the sea water of the Bay of Bengal in the morning hours and from the hills in the north-western region of India in the evening hours. These results are compatible with the observations on the horizontal gradient of ionization in the F_2 region of the ionosphere in the morning and evening hours.

The following papers were published and read in the Science Congress Session held at Ag , 1956.

1. Diurnal Variation of the apparent Reflection Coefficient and total Absorption of Radio Waves in the Ionosphere. (Ind. Sci. Cong.,1956, Abstracts Part III, p. 42).
2. The study of the Angle of Arrival of the Down-coming Radio Waves from the Ionosphere (Ind. Sci. Cong., 1956, Abstracts Part III, p. 463).
3. Abnormal Horizontal Gradient of Ionization in

the F_2 Region of the Ionosphere (Ind. Sci. Cong., 1956, Abstracts Part III, p. 464).

4. Ionospheric Observations at Banaras during the total Solar Eclipse on 20th June, 1955. (J. Sci. Industr. Res., 14A, 517, 1955).

5. Design and Development of a simple Ionospheric Equipment (J. Sci. Industr. Res., 15A, 70, 1956).

LUNAR AND SOLAR TIDES IN THE IONOSPHERE

Mr B.M. Banerjee (Investigator-in-Charge)
Mr Santosh Chandra Nath

A paper on pulse capabilities of readily available receiving and transmitting tubes has been completed and sent for publication in the Journal of Scientific and Industrial Research.

Of the transmitter units the following have been constructed :

1. Variable frequency oscillator for generating oscillations of frequency from 31 Mc/s to 55 Mc/s. It will sweep through this range in half a minute. This has to supply (a) The Transmitter Mixer, (b) The Receiver Mixer, (c) The Frequency Marker Generator.

2. Driver Stage - incorporating five pulse power tubes connected as distributed amplifiers.

Preliminary observations about the performance of these units have been obtained, which are satisfactory. However, both units still await final refiniments.

Besides these, the Master Oscillator, 30 Mc/s Pulsed amplifier and Transmitter mixer are under construction.

TRAVELLING WAVE DISTURBANCES IN THE IONOSPHERE BY SPACED RECEIVER METHOD

Dr B. Ramachandra Rao (Investigator-in-Charge)

Mr Srirama Rao

Mr D.S.N. Murty.

As an extension of the work done during the last half year, a more detailed study of relationship between ionospheric wind velocity, frequency of fading and wave-length of the radiation is made during this period. Fading records taken during December, 1954 and January to March, 1955 on 2.8 Mc/s and during November, 1955 on 2.3 Mc/s, have been used for the purpose of this study. All the fading records have been analysed and the frequency of fading determined by the simple method of counting the number of peaks occurring in a fixed interval of time. The wind velocities estimated by the usual method are separated into groups falling in the ranges 0-10, 10-20, 20-30 m/sec, etc. The average values of velocities and frequencies of fading in each group are taken as representative values for that range and are shown in Table I for both the records taken on 2.3 and 2.8 Mc/s. A graph is then drawn showing the variation of v versus N for both the frequencies and is shown in Fig. I.

TABLE I

Serial No.	Average velocity at 2.8 Mc/s	Average N at 2.8 Mc/s	Average velocity at 2.3 Mc/s	Average N at 2.3 Mc/s.
1.	19 m/s	7.0 peaks/min	-	-
2.	29	8.0	-	-
3.	35	12.5	30 m/s	8.0 peaks/min
4.	45	13.8	44	12.7
5.	55	17.5	53	13.3
6.	64	21.7	-	-
7.	72	22.2	72	16.7
8.	80	23.2	85	20.7
9.	96	28.0	-	-
10.	107	31.7	-	-
11.	115	35.2	110	25.1

It will be noticed that nearly all the points for each frequency lie practically in a straight line passing through the origin confirming the linear relationship between v and N predicted by theory given by previous workers. The most interesting feature of these graphs is that the gradients of these straight lines are different for both the frequencies being less for the observations taken on the lower frequencies. The

actual values of gradients $s_{2.8}$ and $s_{2.3}$ for the two different radio frequencies are determined and found to be .0051 and .0041 respectively. From these values we have

$$\frac{s_{2.8}}{s_{2.3}} = 1.244 \qquad \ldots \qquad \ldots \qquad \ldots \qquad (1)$$

Incidentally, we also find that the radio of frequencies

$$\frac{f_{2.3}}{f_{2.8}} = 1.217 \qquad \ldots \qquad \ldots \qquad \ldots \qquad (2)$$

As (1) and (2) are agreeing well within the limits of experimental accuracy, the gradient $s = N/v$ can be taken to be proportional to frequency f and we can write

$$N/v \propto f$$

or $\quad v \propto N/f$ or $N\lambda$

Hence $\quad v = k\,N\lambda \quad \ldots \qquad \ldots \qquad \ldots \quad \ldots \qquad (3)$

where k is the constant of propertionality.

As a next step, the constant k has been determined for the two sets of values, being 1.829 for 2.8 Mc/s and 1.887 for 2.3 Mc/s. The mean value of k is found to be 1.858.

Thus $\quad v = 1.858\,N\lambda \quad \ldots \qquad \ldots \qquad \ldots \quad \ldots \qquad (4)$

is experimentally arrived at as a relation between v and N. Briggs[1] has derived an approximate expression for N by considering the interference between [illegible] rays which undergo a Dopplor shift of $(2V/\lambda)\sin\theta_0$, so that

$$N = (4V/\lambda)\sin\theta_0 \qquad \ldots \qquad \ldots \qquad \ldots \qquad (5)$$

[illegible]

where θ_o is the maximum angle of the cone into which the downcoming rays are spread, From a comparison of the equations (4) and (5) we can calculate the angle θ_o, which comes out to be 7.72^o. This value agrees fairly well with that of 7.2^o obtained by Briggs[1] from a study of R-f records. Briggs and Phillips[2] define another angle θ_o' which corresponds to the value at which the amplitude of the obliquely arriving rays falls to half that at vertical incidence. From the fact that the amplitude of the obliquely arriving rays falls rapidly for angles greater that θ_o' , the value of $\theta_o' = 5^o$ observed by Bri_gs and Phillips[2] on a frequency of 2.4 Mc/s is agreeing quite well with our experimental value of 7.72^o observed for the two frequencies of 2.8 and 2.3 Mc/s

An important conclusion of our investigation is that the straight line relation between v and N for a particular value of λ also supports the idea that the fading at a point on the ground is mainly due to horizontal systematic movement of ionospheric irregularities and that random motion is not significant. Full details of these investigations are being communicated for publication.

With a view to study the diurnal or semidiurnal variation of wind movements in the E region, if any, a few days in the summar and winter months were chosen and

wind records were taken throughout the day from 0600 to 1800 hours I.S.T. at regular intervals of half or one hour during those days. All the winter records were taken on three consecutive days in November 1955 and the mean values are obtained for the wind velocity and direction for any particular hour. All the summer records were taken on two consecutive days (June-July 1955) and mean hourly values of wind velocities and directions are obtained similarly. The diurnal variations are then depicted graphically by plotting the mean hourly value against the corresponding hour of the day. Though the variation of velocity from hour to hour appear to be irregular, there is a general trend of decrease of wind velocity towards noon, this variation being more prominent during summer than during winter. The hour to hour variation in wind directions is not systematic or regular but a mean line drawn through the various points gives the general trend of variation over a day. During winter there is a general trend towards clockwise rotation from morning to evening of wind direction from about 180° to 290° E of N; and during summer there is a general tendency for anticlockwise rotation of the wind velocity from morning to evening the change being from 180° to 70° E of N. It is interesting to note that the mean wind direction

which corresponds to the noon value for both winter and summer months are consitent with the southwest and south-east directions observed from a study of seasonal variation of wind movements already reported by us[3]. Detailed investigations on this aspect are still in progress as no definite conclusions can be drawn without taking observations extending over a larger number of days.

References.

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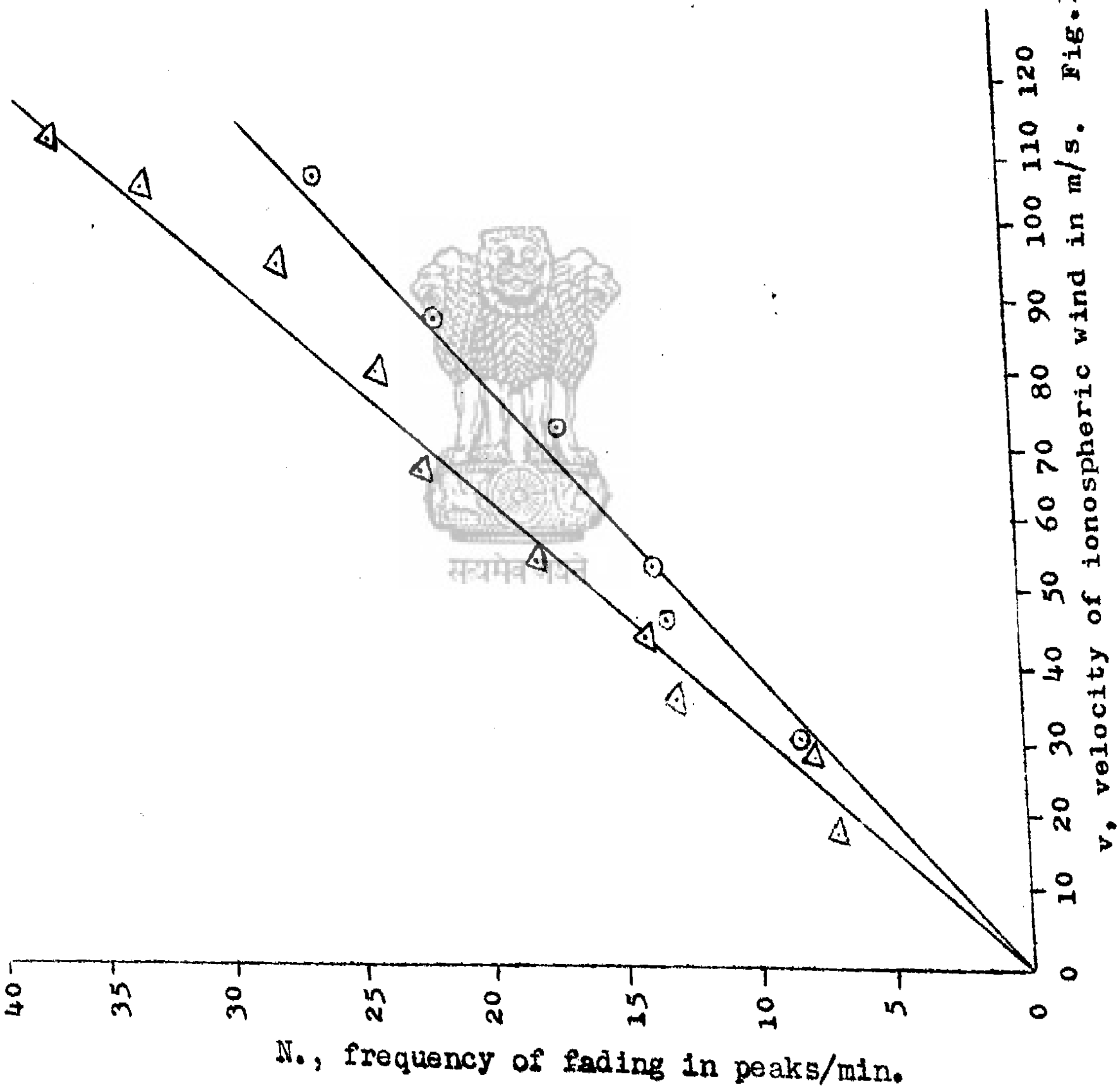

0
5
10
15
20
25
30
35
40
N., frequency of fading in peaks/min.
0
10
20
30
40
50
60
70
80
90
100
110
120
v, velocity of ionospheric wind in m/s.

Fig.III.(5)1.

STUDY OF WIND DRIFTS IN THE E AND F LAYERS OF THE IONOSPHERE

Dr.U.D. Desai (Investigator-in-Charge)
(At present under the supervision of
Dr K.R. Ramanathan)

Mr R. Sethuraman.

1. Mr R. Sethuraman joined as a Junior Research Assistant in the above scheme on 24th January, 1956.

2. New aerial systems, consisting of three half-wave dipoles for reception and two vertical V antennas for transmission were constructed.

3. The transmitting and receiving equipment is being re-conditioned so as to improve the performance.

DESIGN AND CONSTRUCTION OF IONOSPHERE RECORDER

Professor K. Sreenivasan (Investigator-in-Charge)

The construction of the apparatus is proceeding.

PHYSICS OF THE LOWER IONOSPHERE

Dr A.P. Mitra (Investigator-in-Charge)

Components are now being procured for setting up the equipments. To start with, low frequency transmission from the Safderjang Airport (Civil Aviation) will be used.

Work on the development of an empirical D-layer is underway, and a theory of sudden ionospheric disturbances, put forward by the author sometime back, is being amplified.

STUDY OF WINDS IN THE IONOSPHERE

Dr S.R. Khastgir (Investigator-in-Charge)

Mr R. Satyanarayana.

1. Recording arrangement with a moving film camera

For recording continuously the fading of an ionospheric echo received by each of the three receivers, in the three spaced receivers method of studying the iono spheric winds, a recording unit has been developed by employing Cossor's oscillograph camera. The photographic film in the camera is continuously moved by coupling the receiving spindle of the camera with a motor unit fitted with a reduction gear and a suitable pulley arrangement so that the echo produces a continuous trace of its amplitude on the moving film.

2. Continuous recording of the fading of E_s-echoes

The recording arrangement has been used to record continuously the fading of E_s-echo as observed in one receiver. These records are being analysed for calculating the r.m.s. line-of-sight velocity of the ionospheric irregularities and also for determining the auto-correlation coefficient.

3. Erection of the three spaced aerials

For the study of winds by the method of three spaced receivers, three centre-fed horizontal dipole

aerials have been erected. The length of the dipole is about 160 ft. An ordinary twin cable is employed as transmission line for each of the three dipoles. The height of each aerial is about 25 ft. above the ground. The three aerials are arranged at the corners of a right-angled triangle such that their lengths are parallel. The lenght of the two arms of the right-angled triangle is about 300 ft. each.

4. <u>Construction of the gating circuits.</u>

In order to investigate the fading of a single echo, in the experiments on the study of winds, gating circuits are being constructed. A brief description of the circuit is as follows :

From the 50-cycle A.C. voltage, a square wave is generated by employing a 6SJ7 tube. The sharp pulses obtained by differentiating the square wave, are then utilized to trigger the flip-flop circuit which works as a cathode-coupled multivibrator, thereby producing a positive gate-pulse during each cycle. The positive gate-pulse is applied to the suppressor grid of a mixer tube (6AC7), to the control grid of which is applied the signal voltage from the receiver, after limiting in a diode clipper. The suppressor grid is biassed beyond cut-off, so that the mixer functions as an amplifier only during the period when the positive gate-pulse

appears between the suppressor grid and the cathod of the mixer. By means of a phase-shifting net-work it is thus possible to make the gate-pulse coincide with the particular echo meant for study, so that only that particular echo is amplified by the mixer, all the others being suppressed.

The construction of these circuits is in progress.

COMMISSION IV: ON RADIO NOISE OF TERRESTRIAL ORIGIN

1. Study of the nature of atmospherics -
   Dr S.R. Khastgir, Banaras University.

2. Nature and origin of atmospherics -
   Dr M.W. Chiplonkar, Poona University.

STUDY OF THE NATURE OF ATMOSPHERICS

Dr S.R. Khastgir (Investigator-in-Charge)

Mr R.S. Srivastava

1. Wave-form records with the Automatic Atmospheric Recorder.

More than 2000 waveforms of the Atmospherics were photographed with the improved Automatic Atmospheric Recorder at Durga Kund during the months of September, October and November, 1955. Besides the various types of waveforms due to cloud-to-ground discharges, there were evidences of cloud-to-cloud discharges. Many oscillograms showed multiple-strokes with a time-interval of about 2 milliseconds which is considerably smaller than the time-interval between successive strokes in a cloud-to-ground discharge. These multiple discharges showed in many cases (i) 'predischarges' (ii) return stroke (iii) c-field change and (iv) hook-field components.

2. Simultaneous records of the waveforms of Atmospherics and their direction arrival.

The Atmospherics Recorder was operated simultaneously with the cathode-ray direction-finder for the purpose of locating thunder storm centres. The waveforms records showing ionospheric reflections enabled determination of the distance of the source of atmospherics.

The distance and the direction of the arrival of the atmospherics, obtained simultaneously were utilised in finding the latitude and the longitude of the different sources of atmospherics.

3. Polarization of the atmospheric pulses on reflection from the ionosphere.

In the course of the study of the direction of atmospherics elliptic patterns of gradually changing tilt-angle and ellipticity were observed. These have been attributed to the abnormal polarization of atmospheric pulse, the phase-difference between the normal and the abnormal components introduced by the reflections at the ionosphere have been made.

4. Study of Energy Spectrum of Atmospherics in the low frequency region.

Oscillograms of the response of three tuned A/F amplifiers were taken for studying the energy content in the different frequency channels of the atmospherics. Each of the amplifiers was tunable from 3 Kc/s to 15 Kc/s. These preliminary experiments have shown that the maximum of the energy of Atmospherics lies somewhere in the region of 8 Kc/s to 10 Kc/s. It is proposed to extend this work in a more elaborate way in the coming monsoon.

THE NATURE AND ORIGIN OF ATMOSPHERICS

Dr M.W. Chiplonkar (Investigator-in-Charge)
Mr S.M. Vaidya

1. The recording of hourly spot readings for all the 24 hours of the number of X's received per second on the four frequency bands (85 kc/s, 125 kc/s, 175 kc/s and 455 kc/s) has been going on during the whole of the period under report. The continuous recording of the amplitude of atmospherics received on 85 kc/s band is also continued. Occasionally photographic records of the amplitudes of X's received on all the four bands hanve also been secured during the months of Jan. and feb. 1956.

2. It was not possible to obtain good records of the wave forms of atmospherics on the apparatus designed for this purpose. This perhaps may be due to their very small intensity failing to trigger on the automatic brilliancy control.

3. The crossed rectangular loop D.F. system has been completed for one station Poona. As a result of trials over a few days it may be noted that some modifications had to be carried out in the former receivers in order to secure more exact phase relationships in the different stages of the three amplifiers. Now similar unit is being set up at another station at Sangli.

COMMISSION VI: ON RADIO WAVES AND CIRCUITS

** 1. Construction of 100 watt R-C type F.M. Oscillator - Professor H. Rakshit, Bengal Engineering College.

* 2. Millimicrosecond pulse generator - Mr P.V.V.S. Sastry, Madras Institute of Technology.

* 3. Pulsive Tube Characteristic Meter - Mr P.V.V.S. Sastry, Madras Institute of Technology.

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* These schemes where originally undertaken by Professor Filipowsky.

** This scheme was completed in February, 1956. The final report for this scheme will be issued at a later date.

MILLIMICROSECOND PULSE GENERATOR

Mr P.V.V.S. Sastry (Investigator-in-Charge)
Mr T.R. Raman
Mr. M.S. Ramamoorthy

Details of work done during the earlier part of the period have been given in reports 11, 12 and 13. A further detailed report will be sent about the later work. The following is a consolidated report for the entire period.

Experiments with scaled-down model multivibrator were conducted to verify the results obtained by calculation. The main factors that influence the steepness of waveforms were found by calculation. The limit upto which improvement can be obtained by reducing the coupling capacitor was estimated and verified by experiment. Details of calculation and experimental results are given in report 11.

A fast multivibrator circuit with triodes as loads on both tubes was tested. Its main drawn-back was that the out-off characteristics at the grids were very poor. Improvement was effected by eliminating one triode. The best design for the resulting circuit was given in report 12. A comparison of the improvement properties of 6AK5, 6CB6 and 6AH6, with special referance to this circuit, was given in report 12. It was clear

from this that 6AH6 has considerable advantages over others.

After some difficulty, two 6AH6 tubes were procured and two different circuits were built. Although fast rise-time and fall-time could be obtained, there was difficulty in reducing the pulse width. Grid saturation was reduced by putting suitable resistors in series with the grids. Finally it was observed that the cause was the operation running into the bend of the pentode characteristics. One grid had, therefore, to be provided with limiting diode so as not to allow the grid-voltage to go more positive than - 2 to -3 volts (variable). This reduced the flat top considerably from 0.3 μS to 0.05 μS. There is still quite a large amplitude of ~~xxxx~~ about 50 volts. The next step will be to alter the design so as to get a narrower pulse at the expense of some amplitude - it has been mentioned earlier that an amplitude of 20-30 volts will be considered satisfactory if narrower pulses can be obtained.

PULSIVE TUBE-CHARACTERISTICS METER

Professor P.V.V.S. Sastry (Investigator-in-Charge).

During the period from September 1955 to February, 1956, the final-stages of wiring of the unit were completed. Each sub-unit was tested and mounted and inter-unit wiring was done.. The various adjustments have been done. The unit now has to be put into operation. Small unexpected trouble-spots appearing during this process are being attended to. No basic difficulty is expected.

COMMISSION VII: ON RADIO ELECTRONICS

REPORT ON THE RADIO COMPONENTS SCHEME

T. V. RAMAMURTI

So far 27,443 capacitors have been supplied to Messers Radiola Corporation, Tata Institute of Fundamental Research and Indian Meteorological Department. The capacitors supplied to Meteorological Department were used in their 'Rawin' Transmitters which reach heights of eighty thousand feet, and reports are that the capacitors have behaved quite well.

Machines for silvering ceramics automatically have been built. This enables us to handle larger numbers of capacitors. Other machines for soldering tinned copper wire on to the ceramics have also been designed. With these we have been able to partially mechanize the production. Extruding machines for tubular ceramics are now being built. These will be used for making steatite tubes for cracked film resistances. The equipments ordered under the pilot plant scheme are expected to arrive before the end of the year.

B. U R S I NATIONAL COMMITTEE ACTIVITIES

1. <u>Associate Editor for U R S I</u>

Dr A.P. Mitra was appointed as an Associate Editor on behalf of India for the U R S I.

2. <u>World wide Standard Frequency and Time Service</u>

The National Physical Laboratory of India will soon initiate a standard frequency and time service, similar to MSF, WWV etc..

Proposed characteristics of the signals are given below :

1.	Primary standards is to be used	Three 'Essen Ring' type crystal oscillator units, developed by British Post Office, The time signals obtained with this standard will be checked up with the astronomical time computed with an 'Astrolab' transit telescope unit.
2.	Location of the station	New Delhi, India.
3.	Proposed call sign	A T A
4.	Type of service	Experimental
5.	Carrier power	300 Watts. To be increased to 2KW later.
6.	Type of antenna	Vertical dipole
7.	Number of simultaneous transmissions -	One (Three after a few months)
	Number of frequencies to be used.	One (Three after a few months)
8.	Emissions - hours per day	Two hours per day. Will be increased to 22 hours later
	Emissions - days per week	Seven

9.	<u>Standard frequency to be used as Carrier</u>	10 Mc/s (5 Mc/s and 15 Mc/s will be added later)
10.	<u>Standard Modulation frequency</u>	1000 c/s
11.	<u>Duration of tone modulation in minutes</u>	Five for every fifteen minutes
12.	<u>Duration of time signal in the transmission cycle</u>	Continuous
13.	<u>Method of adjusting the time signals</u>	By steps of 50 milliseconds
14.	<u>Transmission cycle per hour</u>	1000 c/s modulation with carrier for 0-5 mts, 15-20 mts, 30-35 mts, 45-50 mts. Pure unmodulated RF for 5-14, 20-29, 35-44, 50-59 mts. Voice code announcements for one minute duration 14-15, 29-30, 44-45, 59-60 mts.
15.	<u>Details of the seconds pulse signals (time signals)</u>	a) The seconds pulse, emitted for the identification of time, will consist of a group of 5 cycles of 1000 c/s signal. b) For the identification of the minutes the signal for the zero second will be lengthened to 45 milliseconds duration (5 groups of seconds pulses emitted as a batch). c) The seconds pulse signal will be transmitted throughout the transmission cycle. d) During the tone period, the seconds pulse will be transmitted, preceded and followed by short interruptions of the modulated transmission. During the unmodulated RF period, the pulse will be transmitted as a modulating wave.

C. IONOSPHERIC PROGRAMME FOR THE INTERNATIONAL GEOPHYSICAL YEAR OF 1957-58

Ionospheric measurements will be undertaken in one form or another, by twelve stations distributed over a wide range of geomagnetic latitudes (18.75°N to 1.3°S). Of these eleven (all excepting Kodaikanal) will receive full a partial assistance from the committee. Of particular importance will be the initiation of the ionospheric station at Trivandrum, which has a magnetic latitude of 0° and a geomagnetic latitude of 1.3°S. India's ionospheric programme is given below (see also Prog. Rep., September 1954-February, 1955).

A. Vertical Incidence Ionospheric Observation

Station	Geomagnetic lat.	Status	Equipment
Delhi	18.75°N	0	Automatic
Ahmedabad	13.60°N	0	Automatic
Haringhata -Calcutta	12.1°N	0	Automatic
Bombay	9.5°N	0	Manual
Madras	3.10°N	0	Manual
Tiruchirapalli	1.3°N	0	Manual
Kodaikanal	0.6°N	0	Automatic
Trivandrum	1.3°S	P	Manual

B. Ionospheric Drift Measurements

Station	Status	Remarks
Ahmedabad	0	Spaced receiver method

Station	Status	Remarks
Waltair	O	Spaced receiver method - terrestrial
Haringhata -Calcutta	P	Spaced receiver method - terrestrial
Delhi (AIR)	P	Spaced receiver method - terrestrial

C. Absorption Measurements

Station	Status	Remarks
Delhi (AIR)	O	Pulse technique
Delhi (RPU)	P	Cosmic Noise method
Ahmedabad	O	Pulse technique and cosmic noise method
Haringhata -Calcutta	P	Pulse technique
Madras (MIT)	P	Cosmic noise method

D. Atmospheric and Terrestrial Radio Noise

Station	Status	Remarks
Delhi	O	Detection of Storms and SEA'S
Calcutta	P	"
Banaras	O	Waveform Study
Poona	O	Waveform Study

E. Scatter Experiments

Station	Status	Remarks
Banaras	Operating	Backscatter.

D. SCIENTIFIC WORK AT COMMITTEE SECRETARIAT

Scientific Personnel

Dr A. P. Mitra, Secretary, In-Charge

Mr R. Parthasarathy

Miss K. A. Sarada

Mr N. V. G. Sarma

Mr N. M. Rao

PROGRAMME

The current programme of scientific work at the committee secretariat is as follows :

Project No.	Title
1.	Coordination, analysis and publication of ionospheric data.
2.	Preparation of forecasts of radio propagation conditions.
3.	Measurement of ionospheric absorption using cosmic radio noise.
4.	Measurement of ionospheric drift from scintillation of radio stars.
5.	Propagation of Low frequency radio waves.
6.	Physics of the Upper Atmosphere.
7.	Solar-terrestrial relationships.

OXYGEN DISSOCIATION IN THE UPPER ATMOSPHERE - A NEW METHOD OF STUDY

A. P. Mitra

1. INTRODUCTION

Oxygen dissociation in the upper atmosphere is an old problem. It has received attention from physicists for over two decades. Dissociation occurs at two wavelength ranges, the more important being in the Schumann Runge continuum beginning at λ 1759 :

$$O_2 + h\nu \rightarrow O(^3P) + O(^1D)$$

Until very recently oxygen dissociation was studied exclusively on theoretical grounds, most of which assumed photochemical equilibrium conditions. The inadequacy of such an assumption was first pointed out by Nicolet and Mange (1952) who showed that particularly above 100 Km, photochemical equilibrium cannot be established and that at these heights moleculardiffusion and mixing must be important. In arriving at this conclusion they used some rocket data on the total content of molecular oxygen obtained by Byram, Chubb and Friedman of the Naval Research Laboratory, Washington.

The rocket method is at present the only experimental method available for the study of oxygen dissociation. Details have recently been made available on

this method and of the results obtained thereby, by Byram et al (1955). The method is based on measurements made by photon counters using two different wavelength ranges: in one, the counter is sensitive only to the band 1425 A - 1500 A near the centre of a Hartley band of molecular oxygen; in the other, the counter is sensitive to a band of X rays, 45 A to 55 A, for which the absorption coefficient (air) is 2.2 - 3 x 10^{-19} cm^2/s. The radiation in 1425-1500 A is only absorbed by molecular oxygen, and so the intensity of the radiation at any height is a measure of the total oxygen content above this height. Byram et al have reported the results of the analysis of the rocket flight made on December 1, 1953, in which the solar intensity was measured over a height of 100-128 km. at the two wavelength ranges mentioned above. It was found that over these height ranges, oxygen is considerably, but not entirely, dissociated, the fraction of dissociation being 0.62 at 110 km., 0.72 at 120 km., and 0.77 at 130 km. No results are yet available for dissociation below 110 km.

In this report we submit an yet another method for the study of oxygen dissociation. Like the rocket method it also depends on certain experimental determinations - in this case, on certain ionospheric parameters. While absolute values are not directly obtained it is

possible to make the necessary conversion with reference values at 80 or 110 km.

2. METHOD

Basically the method consists of experimentally evaluating the parameter λ , the negative ion to electron ratio as a function of height for both day and night conditions. Negative ions are produced by attachment of electrons to atomic and molecular oxygen which form stable negative ions, and then disappear through a number of processes, such as collisional detachment, photo-detachment, and mutual neutralisation. The magnitude of λ at any height will be controlled by the rate coefficients of these various reactions, but will also depend naturally on the concentrations of molecular and atomic oxygens at these heights. In quantitative terms, the relationship between these concentrations and λ for the height range 80 - 110 km. may be written as :

$$\lambda_{\rho}(h) = \left[\beta(O)n(O) + \beta(O_2)n(O_2)\right] / \rho \qquad (1)$$

$$\lambda_{N}(h) = \left[\beta(O)n(O) + \beta(O_2)n(O_2)\right] / K(O)n(O) \qquad (2)$$

where β, K and ρ are the coefficients of attachment, collisional detachments and photo-detachment , and suffixes ρ and N refer to day and night time conditions respectively.

Using equations (1) and (2) we get the following useful expressions :

$$\frac{\lambda_N(h)\alpha i}{\lambda_p(h)\alpha i} = \frac{\lambda_N(h)}{\lambda_p(h)} = 1 + \frac{\rho}{K(O)n(O)} \tag{3}$$

$$(\lambda \alpha i)_N = A + B \frac{n(O2)}{n(O)} \tag{4}$$

where $A = \frac{B(O)}{K(O)}\alpha i$; $B = \frac{\beta(O2)}{K(O)}\alpha i$

It will be noted from Eq. (3) that the ratio of the night time and the day time values of λ is dependent on the concentration of atomic oxygen and is larger, the lower is the value of n(O). It levels off to a constant value of 1 for large concentration of atomic oxygen and is therefore insensitive at heights where n(O) is large. Equation (4), however, can be used over the entire height range. This provides a relationship between night time values of $(\lambda\alpha i)_N$ and n(O2)/n(O) for any particular height. Its value will decrease with the increase in height in a region where oxygen is being dissociated. This is precisely the state of affairs between 80 - 110 km. over which, as will be shown afterwards, $(\lambda\alpha i)_N$ is found to decrease rapidly with height.

3. EXPERIEMTNTAL DATA

As we have mentioned earlier, the experimental data used in this work are the values of λ (or more

precisely $\lambda\alpha i$) for both day and night conditions between 80 - 110 km. These are estimated from the corresponding values of the effective recombination coefficient with the help of the following equations :

$$(\lambda\alpha i)_{\rho} = \alpha - \alpha_D \quad \text{(Daytime conditions)} \tag{5}$$

$$(\lambda\alpha i)_{N} = \alpha_{N} \Big/ \left[1 - \frac{n(x^{+})}{(1+\lambda_N)n_{se}}\right] - \alpha_D \quad \text{(night time conditions)} \tag{6}$$

where $n(x^{+})$ gives the concentration of the atomic ion x^{+} responsible for decreasing the value of the effective recombination coefficient at night, n_{se} is the electron concentration at sunset at the corresponding height and α_D is the coefficient of dissociative recombination.

In a paper on the day-time recombination coefficient, Mitra and Jones (1954) have given the value of the coefficient for noon-time conditions at different heights in the lower ionosphere. Values of ($\lambda\alpha i$) may be estimated fromthese data. These are given in table 1. Values of ($\alpha i)_N$ have also been estimated by Mitra, in a subsequent report (1954), which have since been revised (Mitra, unpublished). The revised values are given in table 1, in the third column. In the fifth column of this table, the values of $\frac{\rho}{K(0)n(0)}$ deduced from these experimental data by means of Eqn. (3) are given.

Table 1.

Experimental Data used for the study of Oxygen Dissociation.

Height	$\lambda_{\alpha i}(cm^3/s)$ Day	Night	$\frac{\lambda_N}{\lambda_\rho}$ (smoothed)	$\rho/K(0)n(0)$
75	6×10^{-7}	-	-	-
80	2.5×10^{-7}	3×10^{-6}	12	11
85	1.5×10^{-7}	1.6×10^{-7}	~ 1	~ 0
90	6×10^{-8}	4.5×10^{-8}	~ 1	~ 0
95	3×10^{-8}	6.5×10^{-8}	~ 1	~ 0
100	2×10^{-8}	1×10^{-8}	~ 1	~ 0
105	5×10^{-9}	4.0×10^{-9}	~ 1	~ 0
110	$\sim 10^{-9}$	2×10^{-9}	~ 1	~ 0

4. STUDY OF EXYGEN DISSOCIATION

4.1 While our main study of oxygen dissociation will involve the use of Eqn. (4), we shall initially examine Eqn. (3) in the light of the computed values of $\rho/K(0)n(0)$, given in column 5 of table 1.

It will be noted that this ratio is quite large at 80 km. (~ 11) but then quickly falls to zero at 85 km., and remains so upto 110 km. There is a small rise in the value at 95 km. and again at 110 km. It is, however,

difficult to say at present if these are significant and it seems safe to assume now that they are caused by cumulative errors in the various experimental determinations.

It is possible to obtain some qualitative informations about oxygen dissociation from the above results. Firstly, we may conclude that dissociation proceeds very rapidly above 80 km., so that the concentration of atomic oxygen increases by a factor of more than 10 in 5 km. Secondly we conclude that at all heights above 85 km, $n(O) > \rho / K(O)$. Now the actual values of the rate coefficients ρ and $K(O)$ are not known. But one may set a minimum limit for the ratio $\rho / K(O)$. ρ is not likely to have a value less than 5×10^{-3}/s (Bates and Massey, 1951), while $K(O)$ will probably not exceed $10^{-14}cm^3/s$. Hence the minimum value for $\rho / K(O)$ is $5 \times 10^{11}/cm^3$, thus indicating that at all heights above 85 km (up to 110 km), $n(O) > 5 \times 10^{11}/cm^3$.

4.2 We will now study of oxygen dissociation with the help Eqn. (4). In this, the value of A must be small in comparison to $(\lambda\alpha i)_N$ excepting perhaps at and above 110 km. Now we notice that $(\lambda\alpha i)_N$ is still decreasing at 110 km; this would indicate that A must be about $10^{-9}cm^3/s$ or less. We use in what follows a value of $10^{-9}cm^3/s$. The error involved must be small

for the lower heights, where $(\lambda\alpha i)_N$ is several orders larger than this value. Using $(\lambda\alpha i)_N$ values given in table 1, we may now calculate the values of $B\,\frac{n(O_2)}{n(O)}$ between 80 - 110 km. The results are shown in Fig. 1, which gives the height variation of the parameter $\left[\frac{n(O_2)}{n(O)} \Big/ \frac{n(O_2)}{n(O)}_{80}\right]$. It will be noticed that there is a very rapid fall in the ratio from 80 to 110 km. This indicates that molecular oxygen is considerably dissociated in this region. Consider now a case in which oxygen is almost wholly undissociated (1%) at 80 km. and almost completely dissociated (99%) at 110 km. For such a case $\frac{n(O_2)}{n(O)}$ decreases by factor of about 10^{-4}. We may compare this value with the estimated factor 3×10^{-4}. This then indicates that dissociation is almost entirely confined within the range of 80 - 110 km, with negligable dissociation at 80 km and almost complete dissociation at 110 km.

Let x(h) be the fraction of O_2 dissociated at level h. then

$$\frac{n(O_2)}{n(O)} = \frac{1-x}{2x}$$

In order to calculate x, it is necessary that the value of the constant B be known. B may be computed from a reference value at 80 km, which is obtained

as follows :

Theory shows that at 80 km photochemical equilibrium is established within a few minutes, and so at this height the distribution of atomic oxygen obtained from considerations of photochemical equilibrium should not be greatly in error. An evidence in favour of this conclusion is the calculation recently made by Johnson et al (1952) on the formation of ozone in the upper atmosphere. Ozone is formed by the threebody recombination of molecular oxygen with atomic oxygen. Calculations made by Johnson et al on the concentration of ozone on the assumption of photochemical equilibrium agreed well with the values obtained from rocket measurements over the height 40-90 km. Similar calculations on atomic oxygen should, therefore, be correspondingly correct. If we accept this, then we may write, for the concentration of atomic oxygen at 80 km, a value of $2.7 \times 10^{11}/cm^3$. The corresponding concentration of molecular oxygen computed from rocket observations of pressure and density, is $8.6 \times 10^{13}/cm^3$, so that $\frac{n(O_2)}{n(O)}$ at this height is 3.2×10^2.

Hence

$$B = 9 \times 10^{-9} cm^3/s.$$

We may now compute, with this value of B, the

absolute values of $\frac{n(O_2)}{n(O)}$ over the heights 80 - 100 km. and hence of x. These are also shown in Fig.D.1.1. It will be noticed that, according to our calculations, the fraction of dissociation at 100 km is 0.82. This may be compared with the values given by Byram at al which are 0.95 for the atmospheric model obtained by rocket measurements of pressure and density and 0.62 for the revised model given by Hulbert (1955) based on certain X-ray measurements.

Incidentally, it may also be pointed out that the value of B deduced from above agrees well with the theoretical value of B which may be computed from reasonable values of the rate coefficients involved. These coefficients are $\beta(O_2)$, K(O) and αi. The value of $\beta(O_2)$ estimated by Biondi (1951) from microwave measurements is about $1.5 \times 10^{-15} cm^3/s$. Reasonable values of the other coefficients are :

$$K(O) = 10^{-16} cm^3/s$$
$$\alpha i = 5 \times 10^{-8} cm^3/s$$

so that

$$B = 7.5 \times 10^{-9} cm^3/s$$

which agrees well with the value of B given above.

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THE EFFECT OF MUTUAL IMPEDANCE DUE TO THE NEIGHBOURING ELEMENTS ON THE DRIVING POINT IMPEDANCES OF A LINEAR ARRAY *

R. Parthasarathy

In a Linear Array consisting of n collinear dipoles, spaced d meters apart (centre to centre) and operating on a wavelength of λ metre, the polar diagram in any longitudinal plane is given by

$$E = \frac{\mathrm{Sin}(n\theta/2)}{n\,\mathrm{Sin}(\theta/2)}\text{, where}$$

$$\theta = \left[\frac{2\pi d}{\lambda}\,\mathrm{Sin}\theta + \delta\right]\text{,}$$ δ being the extra phase introduced to swing the beam away from the array normal. Universal Pattern Charts are available to compute the polar diagram for any given values of n, d and λ .

This paper is primarily concerned with the variation in the driving point impedance of the individual dipoles, as a result of continuously varing δ over a range. This variation can be easily traced to the presence of mutual impedance between neighbouring dipoles. Thus if Z_o and Z_m are the self and mutual impedance respectively, the set of equations describing the array

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* A detailed paper on this topic has been communicated for publication in the Jr. of Telecomm. Eng., India.

can be written down as

$$Z_oI_1 + Z_mI_2 + 0 + 0 \ldots\ldots\ldots\ldots\ldots\ldots = E_1$$

$$Z_mI_1 + Z_oI_2 + Z_mI_3 + 0 \ldots\ldots\ldots\ldots\ldots\ldots = E_2$$

$$0 \times I_1 + Z_mI_2 + Z_oI_3 + Z_mI_4 + 0 \ldots\ldots\ldots = E_3$$

and so on ; where E_1, E_2, E_3 are the impressed voltages in the dipoles 1, 2, 3 etc. of the array. If E_1, E_2, E_3 etc. are known then the driving point impedances for the rth dipole is obtained by solving for I_r, since

$$Z_r = \frac{E_r}{I_r}$$

After dealing with the generalized case of n dipoles, the paper goes into the case of n = 4. With such an array where the beam is swung to look in a direction ϕ from the normal the consecutive e.m.fs at the various dipoles will be progressively changing by a phase angle $\theta = \frac{2\pi d}{\lambda} \sin\phi$,so that they form a series E_1; $E_1e^{-j\theta}$; $E_1e^{-j2\theta}$; $E_1e^{-j3\theta}$ and so on.

In this case the driving point impedances of the individual dipoles for an oncoming plane wavefront are given by

$$Z_1 = \frac{E_1}{I_1} = \frac{\Delta}{Z_o^3 - 2Z_oZ_m^2 - Z_\theta(Z_mZ_o^2 - Z_m^3) + Z_{2\theta}Z_m^2Z_o - Z_{3\theta}Z_m^3}$$

$$Z_2 = \frac{E_2}{I_2} = \frac{\Delta}{Z_o^3 - Z_oZ_m^2 - Z_\theta Z_mZ_o^2 + Z_{2\theta}Z_oZ_m^2 - \frac{1}{Z_\theta}(Z_mZ_o^2 - Z_m^3)}$$

$$Z_3 = \frac{E_3}{I_3} = \frac{\Delta}{Z_o^3 - Z_oZ_m^2 - \frac{1}{Z_\theta} Z_mZ_o^2 + \frac{1}{Z_{2e}} Z_oZ_m^2 - Z_e(Z_mZ_o^2 - Z_m^3)}$$

$$Z_4 = \frac{E_4}{I_4} = \frac{\Delta}{Z_o^3 - 2.Z_oZ_m^2 - \frac{1}{Z_e}(Z_mZ_o^2 - Z_m^3) + \frac{1}{Z_{2e}} Z_m^2 Z_o - \frac{Z_m^3}{Z_{3e}}}$$

where $= Z_o^4 - 3Z_o^2 Z_m^2 + Z_m^4$

and $Z_\theta = e^{-je}$

$Z_{2e} = e^{-j2e}$

$Z_{3e} = e^{-j3e}$

Curves have been drawn for the Zs magnitude as well as phase taking Z_m from Carters formula and assuming $Z_o = 73 + jo$ for various values of θ. From the nature of the curves it is evident that it is best to avoid spacings below .25λ between the ends of the adjacent dipoles, in view of the fact that as the beam is required to look at various values of ϕ, the driving point impedance change brings about a fair amount of mismatch as well as unwanted introduction of extra phases.

The paper is confined to the case where the array is 'free' in space, i.e, without being backed up by a reflector. The cases involving a few typical reflectors are as yet under computation.

THE C.W. SIGNAL SOURCE AS A CALIBRATOR FOR A HIGH LEVEL SOURCE OF RANDOM NOISE *

R. Parthasarathy

The paper briefly discusses the problem of using a Signal Generator to calibrate against a high level random noise. The ~~xxx~~ usual procedure is to equate a random noise input $V_n^2 B$ which has given a certain D.C output by pumping in signal power to give the value of output such that $E^2 \times G_o = V_n^2 \int G\, df = V_n^2 G_o B$. Knowing B and E^2, one gets V_n^2.

However, this involves the unavoidable error due to the Signal Generator atenuator, often quite appreciable. Moreover, this assumes that the receiver response is identical to noise type e.m.f. as well as sinusoidal e.m.f. In view of the random nature of the instanteneous value of noise power of r.m.s. value $V_n^2 B$, there occurs a certain amount of clipping in the receiver. It has been shown that when the receiver is linear upto an amplitude V_o either side of the working point, this clipping effect can be confidently neglected for noise power inputs not exceeding $\frac{V_o}{2.5}$ volts r.m.s.

The response of the second detector for a signa

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* See also Parthasarathy, R. Scientific Report No.3, Radio Research Committee, India.

In presence of random noise has been studied by R.A. Smith[1], S.O. Rice[2], V.R. Bennet[3] and Ragazzine[4]. When the detector has a square law characteristic, the direct current depends only upon the actual power input, irrespective of whether the power is sinusoidal or random in nature. However, in the case of a linear detector, the direct current is given by :

$$i_x = b_x \frac{\sqrt{V_n^2 B}}{\sqrt{2\pi}} \times C(s)$$

where $V_n^2 B$ = r.m.s. noise input

$s^2 = \frac{\text{Signal power}}{\text{Noise power}}$ at the input

i_x = resultant D.C. current

b = detector constant

such that $i = b_v$ for $V > 0$

$= 0$ for $V < 0$

$C(s)$ = a function of s.

Also when $s \to 0$, $C(s) \to 1$ (pure noise input) and when $s \to \alpha$, $C(s) \to \frac{2s}{\sqrt{2\pi}}$ (corresponding to the case where a signal has been fed in to give the same D.C. as has given by a high level random noise).

From this relation it has been shown that where the signal generator output is adjusted to give the same detector amount as was given by a high level random noise input to the receiver V_n^2B, then this signal output is not equal to V_n^2B, but is only $\frac{V_n^2 B}{1.13^2}$.

It may be emphasised that in finding the noise factor of a receiver with linear detector using a signal generator, the signal power should be adjusted until it increases the current in the detector (due to receiver noise) by 50% and not 41% as is often done. This arises out of the fact that the extra contribution i_s to the detector current.

$$i_s = \frac{bP}{\sqrt{8\pi\, W_0\delta f}}$$

where $W_0\delta f$ is the receiver noise power fed into the detector along with signal power P. And since the current due to receiver noise alone $i_x = b\left(\frac{W_0\delta f}{2\pi}\right)^{1/2}$

$$\frac{i_s}{i_x} = 0.5 \quad \text{where } P = W_0\delta f$$

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3. W.R. Bennet, Response of Linear Rectifier to Signal and Noise, B.S.T.J. <u>23</u>, 97, (1944)
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INVESTIGATION OF IONOSPHERIC DRIFT USING 60 Mc/s RADIATION FROM DISCRETE EXTRA TERRESTRIAL SOURCES

R. Parthasarathy

The construction of an equipment for recording the intensity fluctuations of discrete radio sources at 60 Mc/s is now in progress. It is proposed to have 3 receivers with suitable aerial systems at centres separated by about 4 km. from each other. Further details will be available soon after the completion of the equipment.

The work is undertaken in Delhi is response to the recommendation of the 1954 meeting of the U R S I.

IONOSPHERIC ABSORPTION BY COSMIC RADIO NOISE AT 20.1 Mc/s

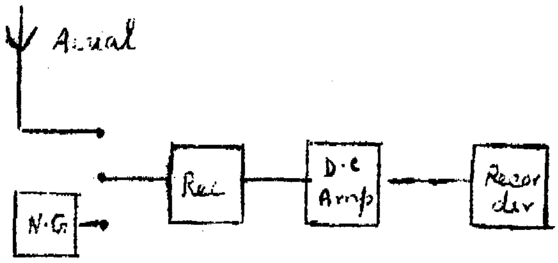
Miss K.A. Sarada

An experimental programme is underway for the measurement of ionospheric absorption by cosmic radio noise at 20.1 Mc/s. The equipment setup is given in Fig. D.5.1(a) and D.5.1(b).

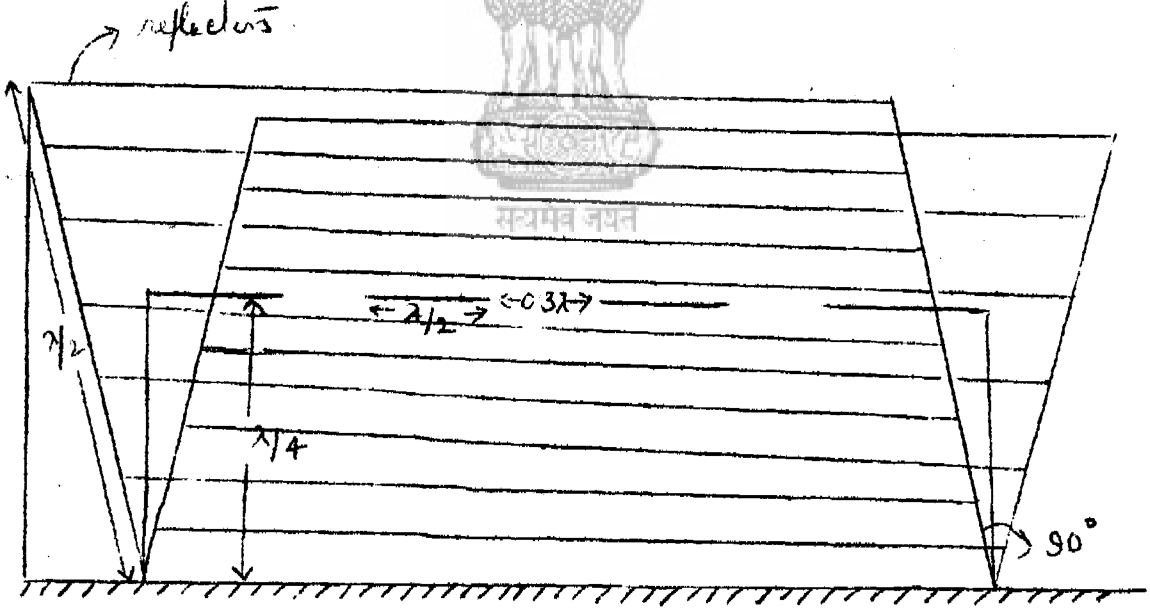
Aerial : Consists of four dipoles provided with corner reflectors as shown in Fig. D.5.1(b). The four dipoles are centrefed and are joined together by T- net works. The beam width in the vertical direction is about $\pm 12^{\circ}$.

Diode Noise Generator : A diode noise generagor has been constructed having the same output impedance as the antenna, to work at a frequency of 20.1 Mc/s, used for calibration purposes.

Receiver : Eddystone 680x receiver is being used, which has a band width of 4 kc/s.



(a) Schematic diagram of the set up



(b) The aerial system consisting of four dipoles with corner reflectors.

Fig. D.5.1

SOME ASPECTS OF THE GEOMAGNETIC DISTORTION OF THE F2 REGION AT EQUATORIAL LATITUDES*

N.V.G. Sarma and A.P. Mitra

The daily variation of the critical frequency of the F2 layer at the equatorial stations shows an abnormal decrease during moontime referred to occasionally as the noon 'bite-out' and the consequent appearance of two maxima. This abnormal behaviour confines itself to stations well within the geomagnetic anomaly belt. Detailed study of the noon bite-out may, therefore, be of some value in understanding the cause of the geomagnetic distortion of the F2 region. Such a study has been made for five equatorial stations, e.g. Madras, Tiruchirapalli, Kodaikanal, Leyte and Huancayo, having magnetic dip values less than ± 15°.

The following results have been obtained :

(1) There is, in general, considerable asymmetry in the diurnal variation in the bite-out, the afternoon maximum being normally greater than the forenoon one. If one writes $P_{1,2} = \frac{f_{1,3} - f_2}{f_2}$ where f_1, f_2, f_3 denote respectively the critical frequencies at the times of the forenoon maximum, midday minimum and afternoon

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* Communication to colloque International sur la propagation des ondes, Paris, 1956.

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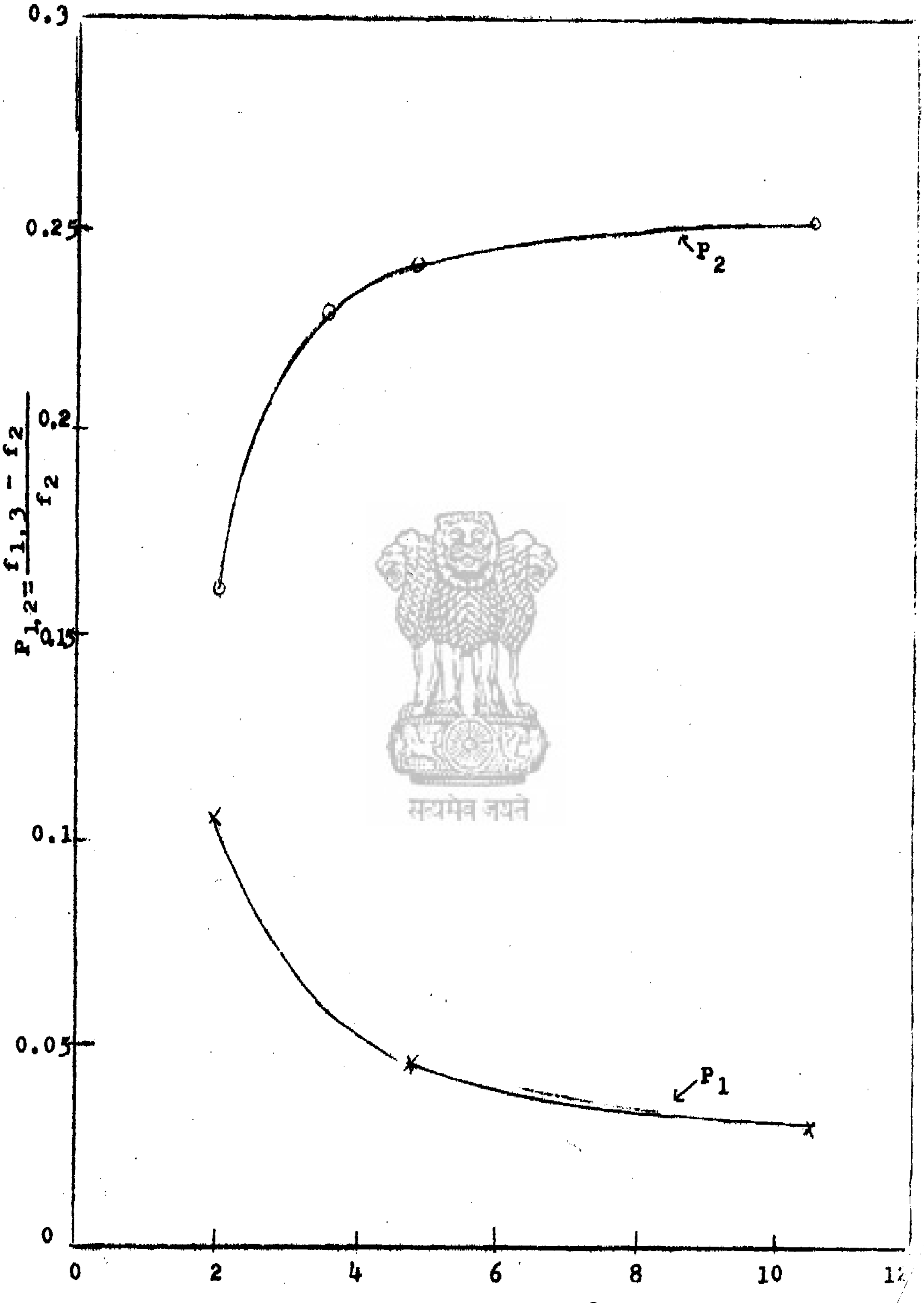


FIG. D.7.1. VARIATION OF P_1 & P_2 WITH MAGNETIC DIP FOR THE YEAR 1954

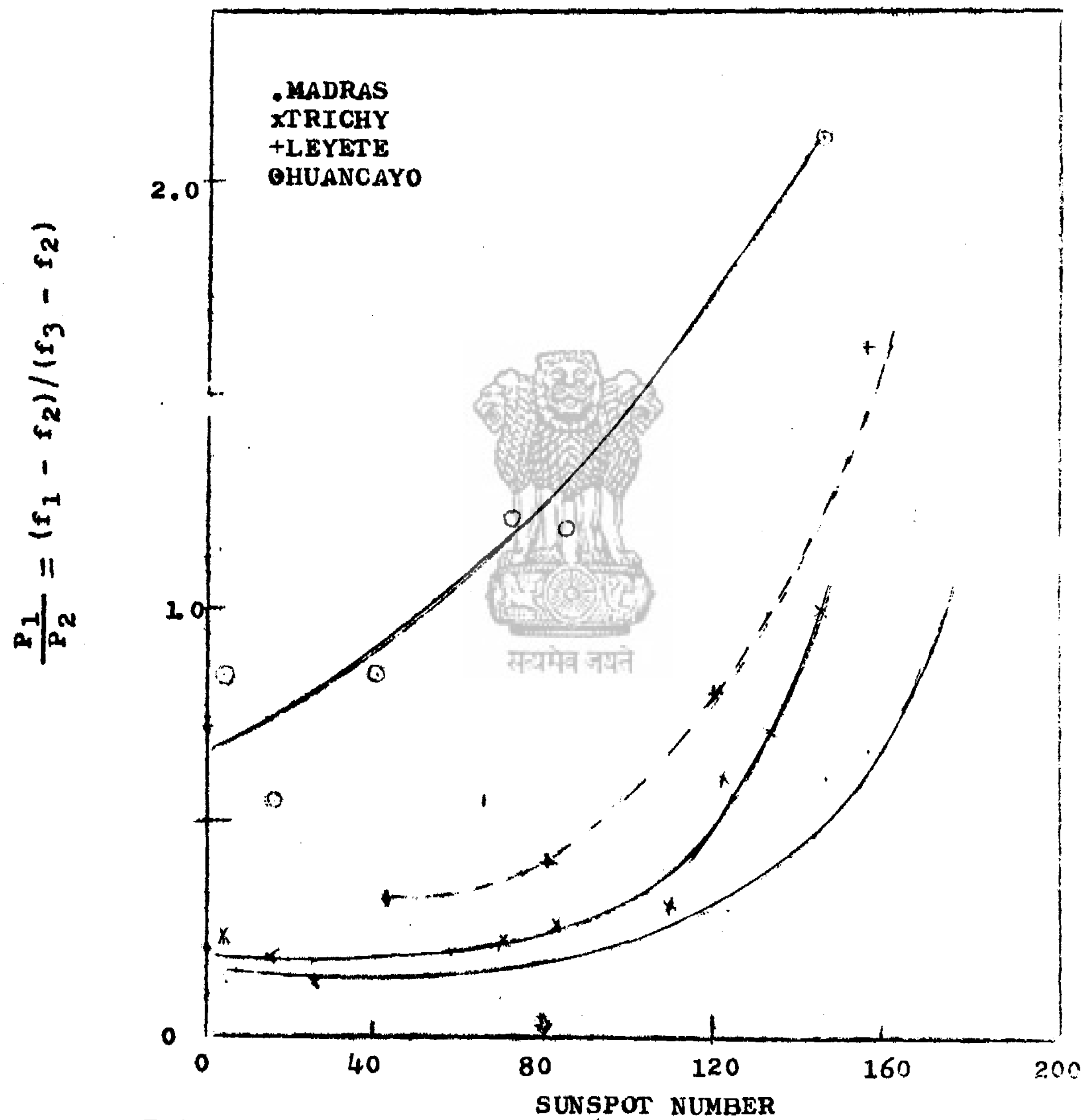


FIG. 1.7.2. VARIATION OF P_1/P_2 WITH SUNSPOT NUMBER FOR E-MONTHS FOR DIFFERENT STATIONS.

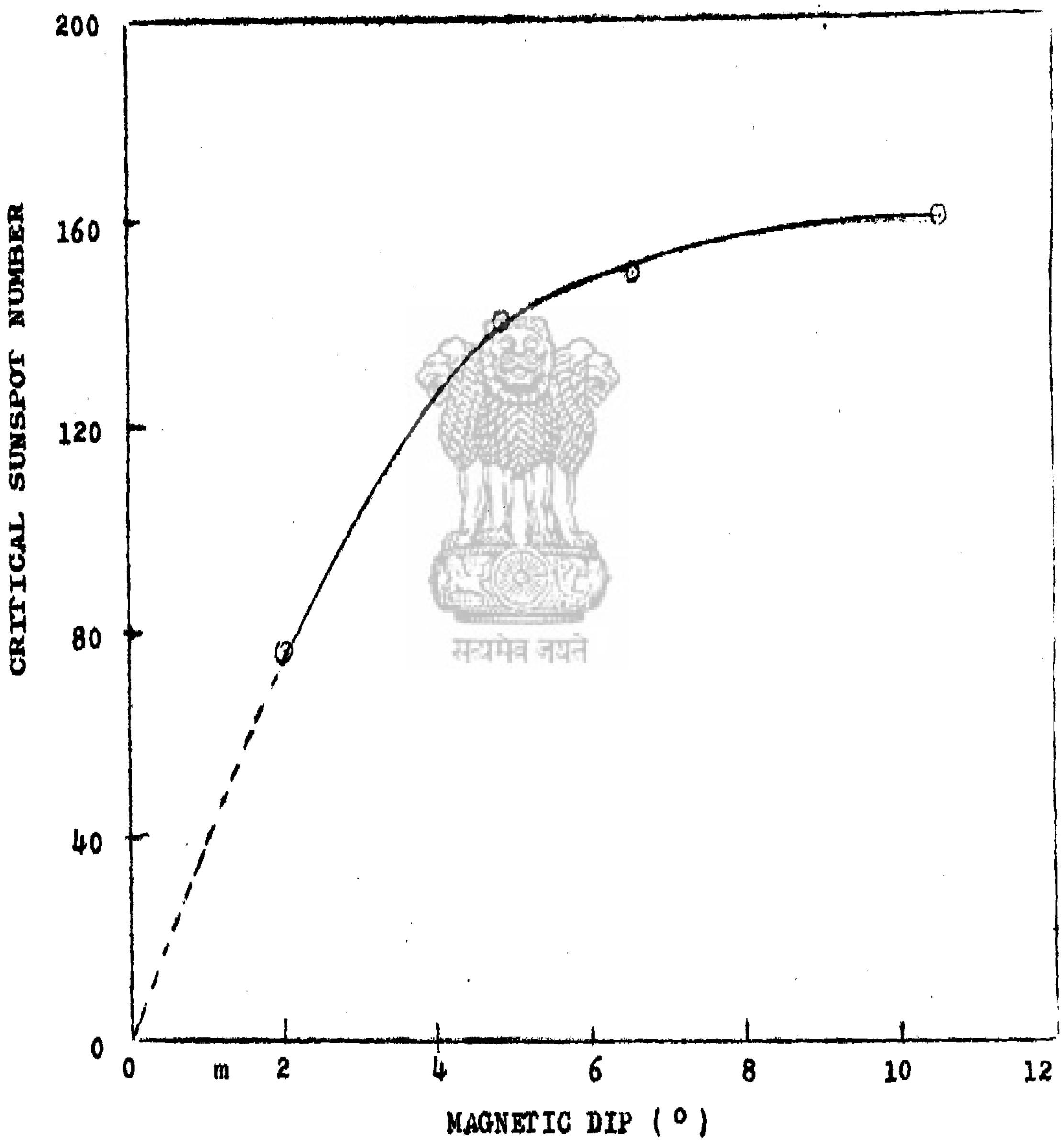


FIG. U.7.3 VARIATION OF THE CRITICAL SUNSPOT NUMBER WITH MAGNETIC DIP

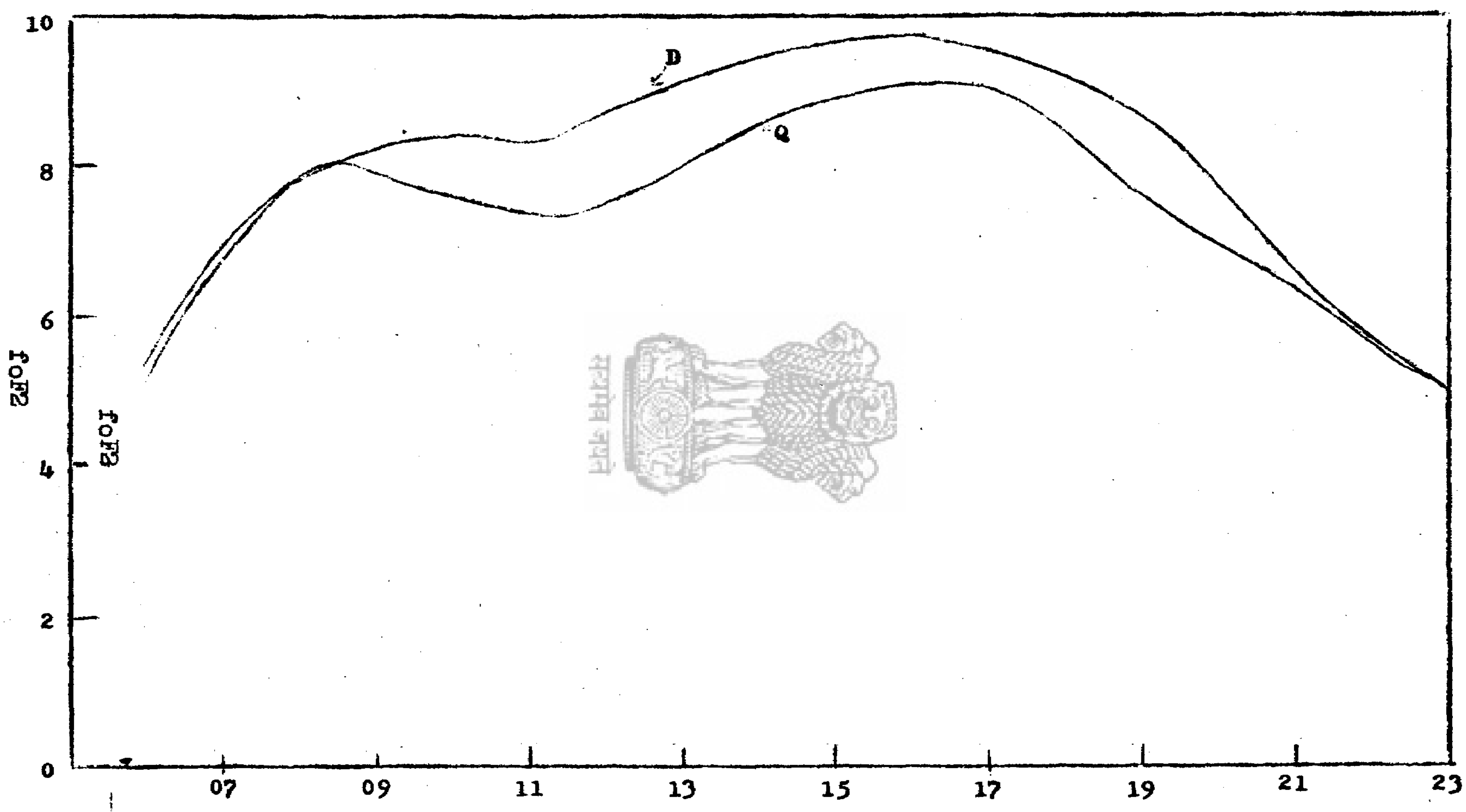


FIG. AVERAGED DISTURBED AND QUIET DAY VARIATION OF foF2 AT DJOBOUTI FOR THE FIRST HALF of 1953

disturbed times and that the distortion decreases slightly, but in no case the complete disappearance of the bite-out phenomenon is observable. (Fig.4)

(6) The height (hpF2 or the inverse of (M3000)F2 analysis for the stations Madras, Tiruchirapalli and Huancayo was also carried out and the following results have been obtained :

(i) The maximum at noon time shifts towards evening as the sunspot number increases. This in our opinion is related to the gradual increase of P_1/P_2 with sunspot number indicated under (2)

(ii) The relation between hpF2 and foF2 at the equatorial stations cannot be represented by a single equation since it is found to be dependant upon the local time and the latitude of the station.

(iii) There is a great rise in the height of the F2 layer maximum at the time of bite-out. In other words the layer is vertically expanded at this time.

BREAKING OF THE E LAYER AT NIGHT

N. M. Rao and A. P. Mitra

It has been observed at the Pennsylvania State University that ionospheric echoes normally occuring from a height of about 100 km (at 150 kc/s) disappear temporatily on certain magnetically disturbed nights, and reflections from a higher height of 150 km simultaneously appear. This has been called the '150 km echo'. A few hours after the jump, the echoes again start appearing at the original level.

In 1954 H.R. Peiffer and A.P. Mitra advanced the suggestion that this anomalous experimental observation may be due to a breaking of the E-layer at times of strong geomagnetic disturbance, caused by enhanced vertical ion transports at this time. It was found that drifts of amplitude about 20 km/hr did indeed break the E layer a few hours after sunset, but there was no reformation in the absence of any nocturnal source of ionization.

The nocturnal ionization in the E-layer has since been studied in detail by A.P. Mitra (1954). His conclusion is that in this layer the night time ionization consists of a molecular ions YZ^+, which disappear through dissociative recombination with a coefficient of about $10^{-8} cm^3/s$, and atomic ions, X^+, the concentration of which

stays practically constant at night. For such a case the constinuity equation becomes :

$$\frac{dN}{dt} = - \alpha_D N^2 + \alpha_D Nn(X^+) - \frac{\partial}{\partial Z}(Nv) \qquad (1)$$

where v is measured positively upwards.

If we confine ourselves to the height of maximum ionization $\frac{\partial N}{\partial Z}$ becomes zero, and so :

$$\frac{dNm}{dt} = - \alpha_D N_m{}^2 + \alpha_D N_m n(X^+) - Nm\frac{\partial v}{\partial Z} \qquad (2)$$

Solving this equation we get :

$$N_m = \frac{N_s(z_m)e^{(\phi-\phi_o)}}{1 + \alpha_D N_s(z_m)\int_o^t e^{(\phi-\phi_o)}dt}$$

where $N_s(z_m)$ is given by the sunset electron-density at the height of maximum ionization,

$v = v_o e^{pz}\sin(\omega t + e)$

$\omega = 30^o/hr$

Z = reduced height $= \frac{h - h_m}{H} = \frac{h - 115}{10}$

$\phi = \alpha_D n(X^+)t + \frac{P\, v_o e^{Pz_m}}{\omega}\cos(\omega t + \theta)$

$t = 0$ at 18 hrs

$\phi_0 = 0$ at $t = 0$

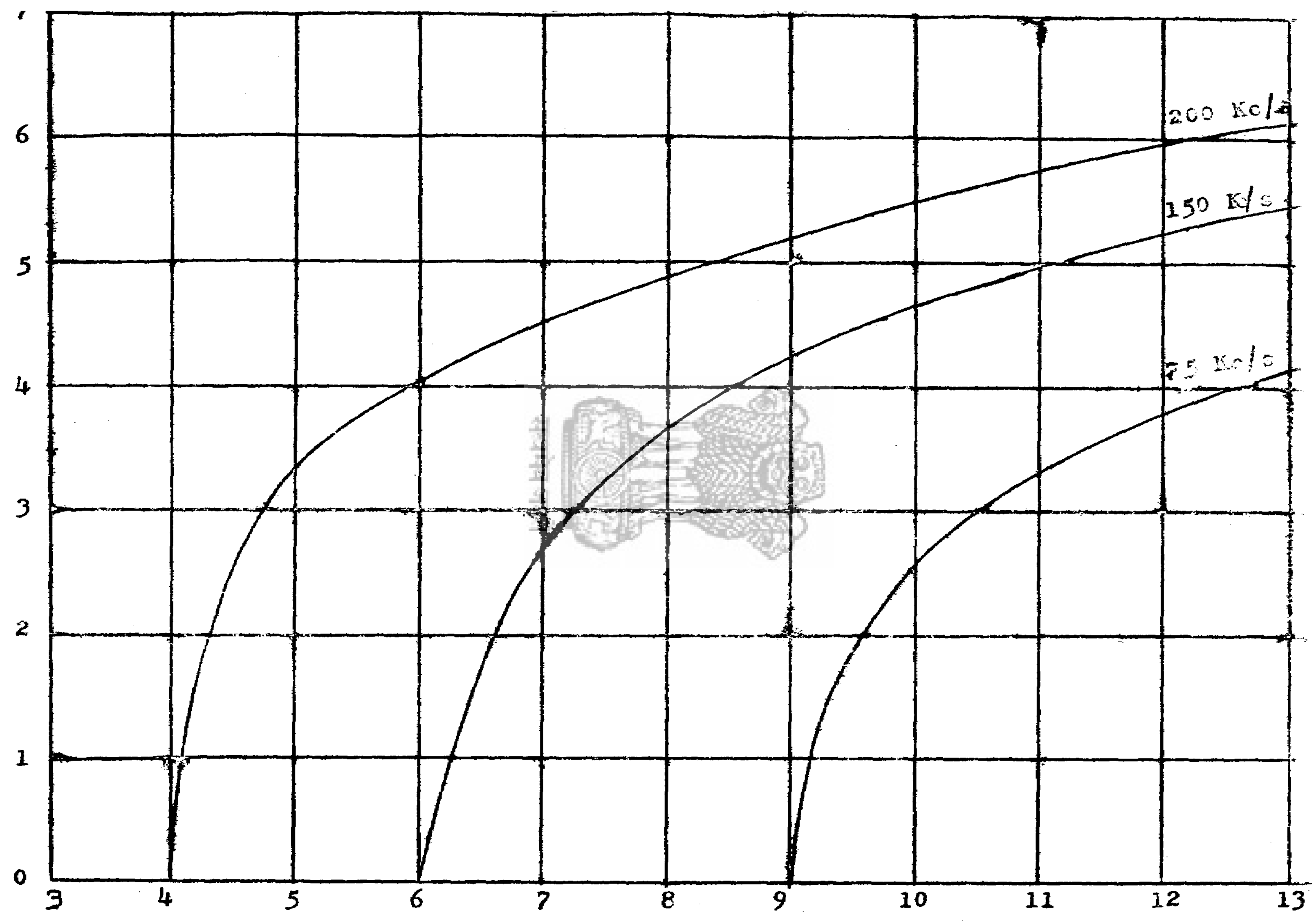
For low latitudes $\theta = 0^o$ ~~at t = 0~~

<u>Simplified solution</u> :- A simple way of judging the effect is, of course, to assume first that the height (height of maximum ionization) variation is nil, which is not too great an approximation, since normally $(h\ max)_E$ does not vary by an amount more than 10 km. When such an approximation is not valid (which may be the case when v assumes higher values) one has to obtain first the variation in height for which the following equation has to used :

$$\alpha_D N_m \frac{\partial}{\partial Z} n(x^+) = \frac{\partial^2 N}{\partial Z \partial t} + N_m \frac{\partial^2 v}{\partial Z^2} + v \cdot \frac{\partial^2 N}{\partial Z^2} \qquad (2)$$

In our first series of calculations, we have assumed that the height variations are negligible and have calculated the values of $(N_m)_E$ at night from the sunset time (i.e. 18 hours) upto 04 hours, for various values of drift velocities from 0 to 20 km/hr.

Breaking and reformation of the E layer at 150 kc/s were clearly noticed from the calculations. The times of breaking and reformation and the total duration during which $(N_{max})_E$ was less than the reflection electron density were plotted against the vertical ionic drift velocity. The results are given in Fig. D.6.1 using these results in conjunction with the experimental results of Lindquist giving the relationship between the total duration of breaking



Theoretical Plot of the vertical Ionic drift velocity versus the duration of breaking of the E-layer

Fig. D.6.1

and K_p- values, one may obtain a relationship between the K index and the vertical ionic drift velocity with E region.

It is also possible to predict the phenomenen of breaking for frequencies other than 75 Kc/s. In Fig. D.6.1, we have given the prediction for such a frequency.